Interference and the Wave Nature of Light

Interference:

Constructive Interference: two identical waves arrive at a point in phase and reinforce each other

Destructive Interference: two identical waves arrive at a point out of phase and cancel each other

⇒ two waves that are initially in phase can arrive at a point out of phase if they travel different distances

\[
\text{constructive interference: } \Delta L = L_2 - L_1 = m\lambda \quad m = 0,1,2,...
\]

\[
\text{destructive interference: } \Delta L = L_2 - L_1 = (m + 1/2)\lambda \quad m = 0,1,2,...
\]

Young’s Double-Slit Experiment:

\[
\begin{align*}
\text{bright fringes: } & \sin \theta = \frac{m\lambda}{d} \\ m &= 0,1,2,...
\end{align*}
\]

\[
\begin{align*}
\text{dark fringes: } & \sin \theta = \frac{(m + 1/2)\lambda}{d} \\ m &= 0,1,2,...
\end{align*}
\]

⇒ use \( y = L \tan \theta \) to find the distance between the fringes

Thin Film Interference:

⇒ the wavelength that is important is the wavelength within the film: \( \lambda_{\text{film}} = \frac{\lambda_{\text{vacuum}}}{n_{\text{film}}} \)

⇒ there is a ½ \( \lambda \) phase change when light reflects from a region with a higher index of refraction

⇒ if only one of the waves undergoes a ½ \( \lambda \) phase change:

\[
\begin{align*}
\text{constructive interference: } & 2t = (m + 1/2)\lambda_{\text{film}} \\ m &= 0,1,2,...
\end{align*}
\]

\[
\begin{align*}
\text{destructive interference: } & 2t = m\lambda_{\text{film}} \\ m &= 0,1,2,...
\end{align*}
\]

⇒ if neither of the waves or if both waves undergo a ½ \( \lambda \) phase change:

\[
\begin{align*}
\text{constructive interference: } & 2t = m\lambda_{\text{film}} \\ m &= 0,1,2,...
\end{align*}
\]

\[
\begin{align*}
\text{destructive interference: } & 2t = (m + 1/2)\lambda_{\text{film}} \\ m &= 0,1,2,...
\end{align*}
\]

Diffraction:

\[
\begin{align*}
\text{dark fringes for single-slit diffraction: } & \sin \theta = \frac{m\lambda}{W} \\ m &= 1,2,3,...
\end{align*}
\]